or more. However, a survey of the literature discloses that previous attempts to isolate the fungus and grow it in pure culture have been unsuccessful. In the absence of pure cultures of the organism, it has necessarily been impossible to prove conclusively that the associated Phytophthora causes the disease.

The present note reports successful isolation of the Phytophthora from strawberry roots, proof of its pathogenicity, and some comments on its behavior in culture.

The fungus was isolated in November, 1937, from roots of diseased strawberry plants growing on the U. S. Horticultural Station farm at Beltsville, Md. Fall roots were well developed at the time, and the fungus was actively attacking the distal fibrous roots and had advanced a short distance up the steles of some of the main roots. Large roots with diseased steles but healthy cortex were thoroughly washed in sterile water, the cortex was carefully removed under aseptic conditions, and the upper 2 cm of the diseased zones were cut in pieces about 5 mm long. The pieces were mounted in a hardened drop of water agar on a coverglass, covered with an additional drop of agar, and inverted over a Van Tieghem cell. Growth of hyphae was followed under the microscope, and either developing hyphae or the entire root pieces, whichever seemed advisable from appearances, were transferred to test-tubes. Approximately 50 per cent. of the pieces yielded Phytophthora in pure culture, or contaminated only with bacteria, which were later eliminated from the cultures. A similar series of isolations from diseased plants collected by Dr. H. W. Anderson near Vermilion, Ill., late in March, 1938, yielded only 4 cultures of Phytophthora out of 45 isolations, most of the others giving a species of Pythium which evidently follows the Phytophthora very closely in the roots.

Pathogenicity was proved by inoculating mycelial cultures and zoospores to roots of potted strawberry plants which had been previously rooted from runners in autoclaved soil. Zoospore inoculation proved to be the simplest method. Abundant infection and some oospore production in fine roots was present six days after inoculation. Under greenhouse conditions wilting began three weeks after inoculation, and at this time the root systems were almost completely destroyed, showing all the characteristic symptoms of naturally infected plants. The organism was recovered in pure culture from inoculated plants by the method used in the original isolations, from the reddened steles of affected larger roots. Uninoculated check plants remained healthy.

The identity of the species is still being investigated. As had previously been determined[6] on its host plant, the fungus belongs to the group of Phytophthoras having large, non-papillate sporangia, comparatively large oospores and predominatingly amphigenous antheridia; but cultural and cross-inoculation studies have so far failed to place it accurately in any described species.

In culture, the Phytophthora grows best on oatmeal agar and in canned pea broth,[7] and somewhat less rapidly on lima-bean agar. Growth is unsatisfactory on all other media tried, including cornmeal agar. Neither sporangia nor oospores have occurred in the culture media tested up to the present time, but sporangia and zoospores develop in abundance when small blocks of mycelium, grown in thin layers of lima-bean agar, are shallowly irrigated with cool tap water. The fungus has a relatively low temperature range, mycelium being killed in one week at 30° C., while zoospores are produced at 10° C., but are inhibited at 22° C., the range of maximum production lying between 14° and 18° C. It is perhaps needless to point out that, together with mechanical distribution of diseased plant parts, zoospore dispersal constitutes the principal means of spreading the disease in the field.

Spore and sporangial measurements of the American red-stele organism come well within the range described for the Phytophthora associated with the Lanarkshire disease in Scotland, and since the symptoms are also similar in most respects, it appears probable that the two diseases are identical.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE MEASUREMENT OF THE EXTERNAL FORCE IN WALKING

FOR an adequate study of human locomotion it is necessary to measure with considerable precision the force exerted on the substratum by the foot at each instant during progression. Since this force is the resultant of the force of gravity and the reaction to the acceleration of the body at the moment, its measurement provides a means of determining the acceleration and so of the force concerned in the movement of the body as a whole. Three measurements are necessary if the force is to be known both as to magnitude and

[6] Ibid.

[7] L. H. Leonian, *W. Va. Agr. Exp. Sta. Bull.*, 262 (p. 13), 36 pp., 1934.

direction. This can best be accomplished by measuring the force in three constant directions, in practise the three axes of rectangular coordinates.

In order to know the torque with which this force acts on the body, it is necessary, in addition, to know the position of the force. Since the horizontal components are situated in the plane of the platform upon which the subject walks, it is only necessary to determine the position of the vertical component in the horizontal plane to effect a complete determination of the force. This position was determined by Elftman and Manter[1] from cinematic records of the distribution of pressure in the sole of the foot, but it can be more easily achieved with the apparatus here described.

The base of the apparatus is so arranged that it can be suspended between two tables. Resting on this base are four vertical compression springs, supporting the lower of two platforms. When a force is exerted on the platform at any point the total compression in the springs measures the vertical component of the force, The relative distribution of this force between the springs depends on the position of the vertical component with respect to the plane of the platform. The quantities to be measured are three in number; it is most convenient to use the vertical displacement of the platform at points 1, 2 and 3 of the diagram. If the displacement is calibrated in terms of the force required to produce it, the sum of the displacements at points 1 and 3 will give the total vertical force and the position of this force can be obtained by equating moments. Although designed for the investigation of movement, this apparatus can also be used for the more traditional measurement of the position of the center of gravity when the body is stationary.

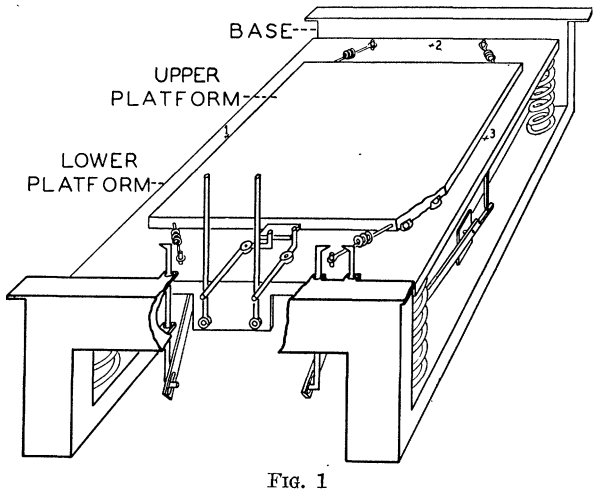

FIG. 1

The horizontal components of force may be measured by means of the displacement of the lower platform in the horizontal plane, since this depends on bending of the springs with respect to their vertical axes. This was proven to be a reliable method by Manter in his investigations on feline locomotion in this laboratory. With the human subject it has been preferable to measure the horizontal components by means of a second platform, parallel to the lower one but separated from it by ball bearings and attached to horizontal springs. From the displacement of the upper platform the components of the force in the direction of movement and lateral to it can be obtained.

The problem of recording the five displacements may be met in various ways. For walking it has been adequately accomplished by lever systems so arranged that the displacements are magnified without distortion and produce movements of indicating levers, all five of which are located in one plane. The indicating levers are photographed with a high-speed cine-camera, the actual speed of which is calculated from the oscillations of a pendulum placed in the photographic field. This camera also provides a record of the position of the foot. For analysis of locomotion another camera is used simultaneously to record the position of the entire individual, walking behind a rectangular grid.

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[1] H. Elftman and J. Manter, SCIENCE, 80: 484, 1934.

A PHOTOELECTRIC COLORIMETER

THIS apparatus is the result of an attempt to construct a photoelectric colorimeter which is relatively inexpensive but both highly accurate and sensitive. Many of the colorimeters available measure the current produced by a single photoelectric cell, a procedure which requires a constant light source, the constancy of which is maintained by variable resistances in the lamp circuit,[1,2] by a trickle charger on to a storage battery,[3] or by a diaphragm placed between the lamp and absorption cell.[4] Some of the difficulties with this method of employing a single cell arise from the variations in the current produced by the cell caused by fatigue and changing temperature. These difficulties can be avoided or minimized by using a variable resistance and a galvanometer as a null point indicator to balance the output of two photoelectric cells connected in opposition.[5] Goudsmit and Summerson[6] employed a balanced circuit, but effected the balance by changing the thickness of the layer of solution through which one of the beams of light passed.

[1] A. Weil, SCIENCE, 79: 593, 1934.

[2] K. A. Evelyn and A. J. Cipriani, *Jour. Biol. Chem.*, 117: 365–369, 1937.

[3] I. M. Diller, *Jour. Biol. Chem.*, 115: 315–322, 1936.

[4] C. Sheard and N. H. Sandford, *Jour. Lab. and Clin. Med.*, 14: 558–574, 1929; 15: 483–489, 1930; *Am. Jour. Clin. Path.*, 3: 405–420, 1933.

[5] H. Hartmann, *Ergeb. d. Physiol.*, 39: 412–449, 1937.

[6] A. Goudsmit, Jr., and W. H. Summerson, *Jour. Biol. Chem.*, 111: 421–433, 1935.